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DEVOTED TO THE SELECTION
AND USE OF LUBRICANTS

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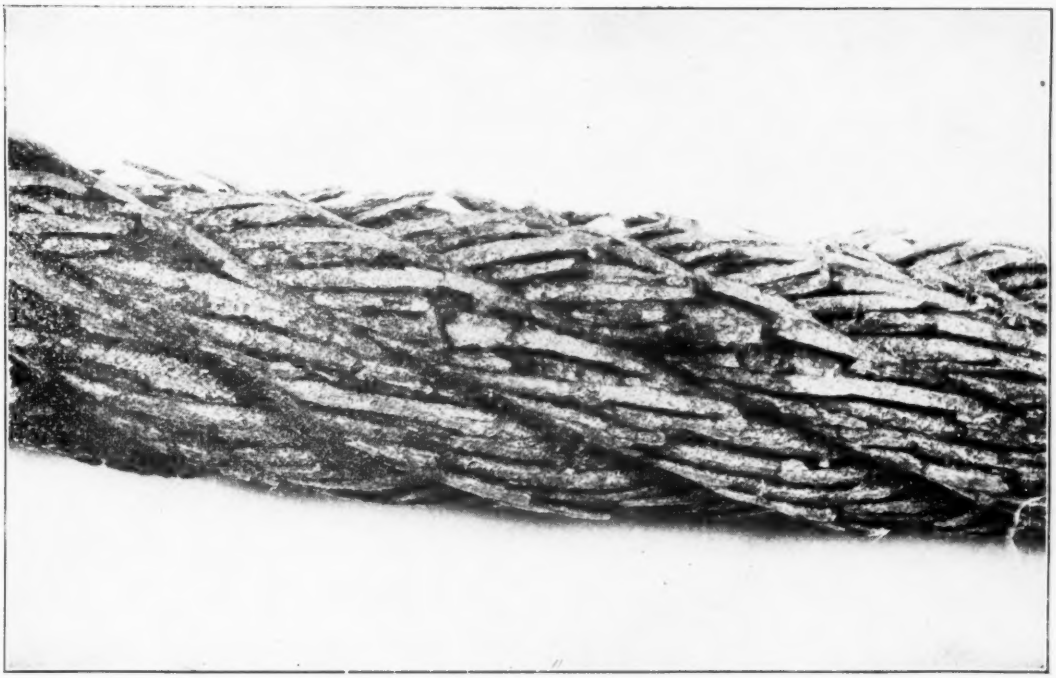


THIS ROPE DRILLED 7000 FEET. A LUBRICATED ROPE DRILLED 22000 FEET UNDER THE SAME CONDITIONS

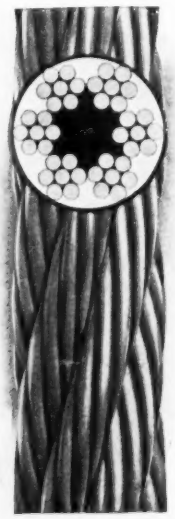
Prolonging the Life of Wire Ropes

WIRE ROPES have become so inseparably linked with modern progress that engineers in all branches of industry are finding it necessary to familiarize themselves with their care and operation. Very little practical information has been published upon these matters, however, so for the benefit of the busy engineer who has neither time nor facilities to make a study of the best way to preserve wire ropes, we are publishing this short article.

The manufacture of rope is of very ancient origin but wire rope is a product of comparatively recent date. As far as known, the first use of wire rope was made in Holland in 1644 but the modern form was not introduced until about 1820. For several decades

wire rope was manufactured in limited lengths by hand, but with the introduction of mechanical appliances the science of rope making gradually advanced until today it has become an industry of considerable proportions.

A wire rope is composed of a number of strands, the strands themselves being made up of a number of individual wires. Different types of ropes are described as having so many strands of a certain number of wires each. Nowadays wire ropes are commonly made with hemp centers although ropes with wire cores can be had if called for.



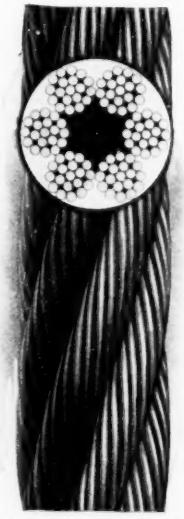
REGULAR LAY ROPE

LANG-LAY ROPE

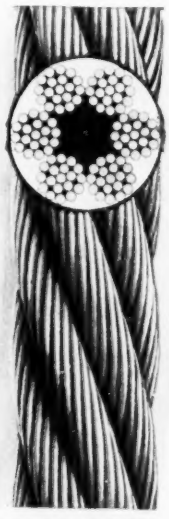
We have all observed that the wires and strands in wire ropes are twisted, but it is possible that we have never noticed that some are twisted differently from others. The primary object of twisting wires and strands is that they may be held together by mutual friction when a load is applied to the whole. Twisting also increases the flexibility to some extent. The relation of the direction of twist of the wires in the strands to that of the strands in the rope is known as the lay. In the so-called regular lay, which is the one most generally used, the wires in the strands are twisted in one direction and the strands twisted into the rope in the opposite direction. In Lang-lay ropes both the wires and the strands are twisted in the same direction. Lang-lay rope is especially suited to resisting external wear. When the strands appear as an elongated right-hand threaded screw, we say the rope has a right-hand lay, and when the reverse, a left-hand lay. Some ropes are made with the wires in half the strands left-hand lay and those in the other half right-hand lay.

On Page 3 are shown the cross sections of 12 different wire ropes and also the methods used in laying them up. The solid black represents a hemp center.

A. The usual form of flexible steel rope, consisting of 6 strands of 12 wires each. This form is much used for hoists, lifts, etc., and is commonly known as compound running rope.



RIGHT LAY ROPE



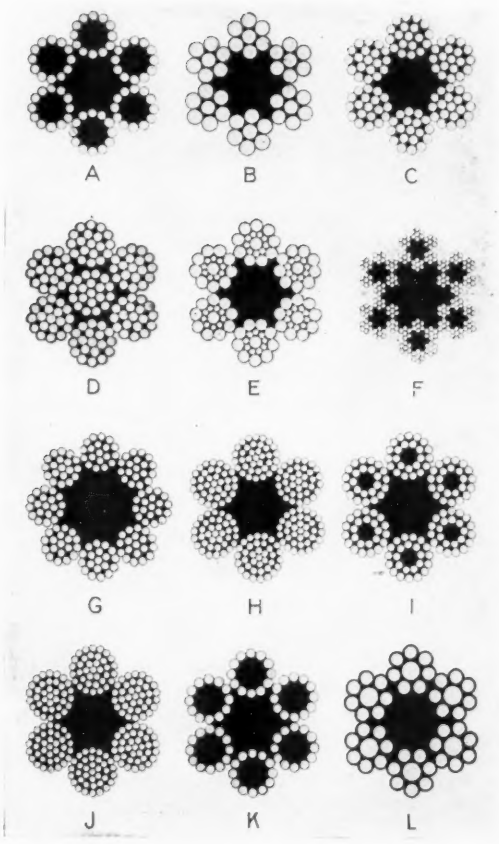
LEFT LAY ROPE

B. This form is known as a haulage, transmission or standing rope. It consists of 6 strands of 7 wires per strand and is suitable for work where the size of sheaves is not too small. Capable of resisting external wear.

C. A hoisting rope, composed of 6 strands, each consisting of 19 wires and laid about a hemp core. Less able to resist abrasion than "B" but considerably more flexible and one of the commonest forms used.

D. Another form of hoisting rope not possessing the flexibility of "C." This rope consists of 6 strands, each of 19 wires, laid around a wire core.

E. This particular form is known as cable



TYPICAL CROSS SECTIONS OF WIRE ROPES

construction and is suited for hauling purposes. It is a stiff form of rope and should not be used where sharp angles are encountered. It will stand considerable abrasion.

F. A form of cable construction commonly called tiller rope. This form is the most flexible made and can be bent around small sheaves, but as it is made of small wires it will stand little external wear.

G. An extra flexible rope composed of 8 strands of 19 wires per strand. This type is very suitable for hoisting and can be used over smaller sheaves than "C."

H. A slightly different form of extra flexible hoisting rope consisting of 6 strands each containing 37 wires. This rope may be used over fairly small sheaves but not under conditions where it will be subjected to external wear. Suitable for cranes.

I. Construction employed in laying up steel hawsers and mooring lines. These ropes are usually composed of galvanized wire.

J. A galvanized hawser similar in construction to the hoisting rope "H."

K. This rope is used for mooring lines and hawsers and with the exception of the fact that the wire is galvanized the rope is very similar to that described under "A."

L. A rope suited for hoisting and deep well drilling.

Prior to 1874 the application of wire rope was limited to those fields in which flexibility is not essential. In that year the first wire rope with a hemp center was produced by the Bullivant Company of London. This was perhaps the most important advance made in rope manufacture. The hemp center made properly fabricated wire ropes available for application where only hemp or cotton ropes could be used before. Today wire ropes have practically superseded other varieties for a great many purposes.

The flexibility of a wire rope depends upon the number of wires of which it is formed, the size of these wires, the method of laying and the nature of the core. Consequently the makeup of a rope limits its field of application. Speaking generally, the greater the number of wires in a rope the greater the flexibility. A first-class wire rope is about as flexible as a new hemp rope having the same strength and can be run over the same size sheave without damage, provided the score on the sheave is arranged to fit the rope.

Wire ropes are expensive and complex pieces of machinery, yet, people who are buying them find it very hard to get the average employee to take the question of their upkeep seriously. It is easy enough to prove to a man that a rope is expensive by telling him the price, but making him realize that the rope is an intricate mechanism is an entirely different matter. Just why this is we are not prepared to state. It is probable, though, that to many men rope is rope and in their minds the wire rope is nothing more than a strong brother of the cotton clothes line in the backyard—something to be used

with no attention to upkeep until it wears out with age and then to be thrown away.

Wire ropes never deteriorate with age. If a properly manufactured wire rope were to be stored away in some place out of reach of water and heat, it would be as fit for use at the end of 10 or 20 years as the day it was made. When wire ropes wear out it is the result of one of three causes:

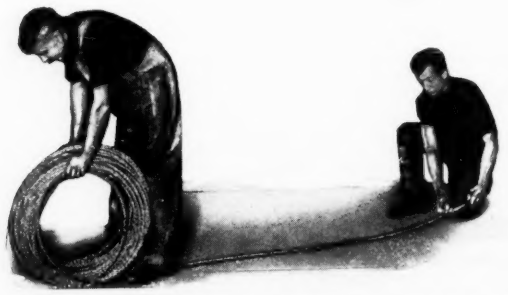
(a) Mechanical abuse.
(b) Neglect.
(c) Long and efficient service.

It is hardly fair to the manufacturer of wire ropes to use one of his products for work for which it is not suited, but it is infinitely more unfair to the man paying the bills. So many varieties of ropes are made now that we might say that there is at least one for every requirement. Consequently, the buyer who pays a lot of money for a haulage rope and runs it over small sheaves has only himself to blame when the rope rapidly wears out. Yet, this happens every day. When buying a wire rope for a particular purpose the purchaser should supply the rope manufacturer with detailed information regarding the operating conditions, and when the proper rope is received it should not be used on another job under entirely different conditions.

THE WRONG WAY TO UNCOIL A WIRE ROPE

Wire ropes are occasionally irreparably damaged during removal from the reel. Wire ropes should never be pulled out of a coil in the manner of hemp ropes, as such practice is bound to cause kinks and twists in the ropes which are hard to straighten out and which weaken them considerably. The correct way to take a rope off a reel is to mount the latter upon an axle so that it may revolve. If the rope can be transferred directly to the drum so much the better.

Wire ropes are very frequently overloaded or subjected to sudden stresses. For long service a rope should not be required to carry more than one-fifth to one-tenth of its ultimate strength, the factor of safety depending upon the conditions of operation. Not only do excessive loads strain the rope but even under the most favorable operating conditions the wires of the rope gradually become worn away and their strength reduced. Sudden jerking and snapping is even more injurious to wire ropes than overloading as the sudden strain may actually cause some of the wires to break. The continuous vibration of long ropes is also very injurious, and especially to ropes which have been allowed to become rusty.



THE CORRECT WAY TO UNCOIL A WIRE ROPE

Poorly designed drums and sheaves are in some cases the entire cause of ropes wearing rapidly. Some wire ropes are made very flexible so that they may be successfully used upon small drums and sheaves, but it should always be remembered that the greater the diameter of drums, sheaves and pulleys, the less the bending action and wear on the rope. The sheave wheels on coal mine shaft hoists are usually about 12 feet in diameter. Grooved drums are much easier on ropes than the flat variety, but unless the grooves are smooth and of slightly greater radius than the rope they will cut and cramp it causing the exterior wires to wear rapidly.

If grooves do not allow a clearance between successive windings rapid wear will also ensue.

Overwinding, that is, the winding of more than one layer of rope upon the drum, is a common form of wire rope abuse. This has the tendency to both cramp and wear the rope and rapidly destroys it. Overwinding is especially injurious when the rope is allowed to climb and become crossed in irregular fashion as this causes severe wear and dangerous jerking. Poor alignment of sheaves and drums causes the rope to scrape against the sheave with the result that both are worn. Wood, leather, or hard rubber properly arranged upon the surface of drums materially reduces the wear of the rope.

If there is one operation that will wear out a wire rope quicker than another it is reverse bending over small sheaves. This subjects the wires in the rope to much the same bending as is employed when we desire to break a piece of wire in our hands, and, moreover, a great deal of frictional wear is caused. The sharper the bend the greater the distance which the component wires must move upon one another. A little care in design will usually make reverse bending unnecessary, but should an idler, or some other device causing this condition be in use, every effort should be made to remove it, and the saving which will thus result through longer rope service will justify the expenditure of considerable money for this purpose.

In steel making, smelting ores, etc., some wire ropes are frequently exposed to intense heat. Although in all cases this can hardly be classed as a misuse, the condition, nevertheless, is the cause of the rapid deterioration of wire rope and should be avoided wherever possible. The heat has the effect of killing the core in the rope and also of drawing out the lubricant so that the rope becomes stiff and wears rapidly. Where intense heat is encountered only ropes having wire cores should be used. Ropes having asbestos cores have been made for use in the presence of intense heat, but have not proved successful because of the rapidity with which the asbestos disintegrates.

In the above paragraphs we have pointed out how a rope may be worn externally, but it should not be forgotten that the interior wires will also wear rapidly unless properly cared for. It may not be common knowledge, but it is a fact, nevertheless, that as the rope passes over the sheaves, etc., a great deal of sliding of each wire upon its neighbors takes place. There is also some slipping of the strands upon one another. When the rope is loaded the wires press upon one another with considerable force so there is bound to be a great deal of frictional wear in the interior unless precautions are taken to prevent it. The proper precaution is efficient lubrication, but more than one rope has gone to the scrap heap for want of it. Perhaps some of our friends would have more respect for the humble wire rope if they only knew that 100 feet of 1-inch wire rope has 334 square feet of bearing surface. A 35,000 H.P. twin tandem reversing engine has been found to have only 319 square feet of surface requiring lubrication.

Serious as are the abuses just described, their effect upon the working life of a wire rope are not to be compared to the injuries

THIS ROPE DRILLED 8,000 FEET. NOTE WEAR ON OUTSIDE WIRES. INTERNAL CONDITION PERFECT

A WIRE ROPE DESTROYED BY CORROSION. NOTE THAT CORE HAS ROTTED AWAY

resulting from neglect. Deterioration caused by abuse is chiefly of a mechanical nature, but that caused by neglect may be said to be chemical, and because of its insidious nature much more serious.

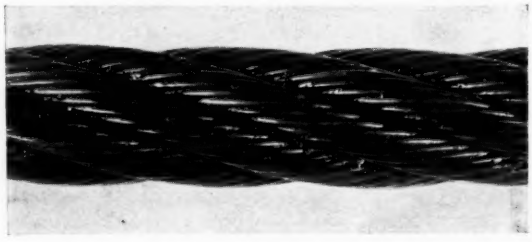
The whole story of the chemical destruction of wire ropes may be summed up in one word—corrosion. Corrosion may be caused by damp air, acid fumes and water charged with chemicals. Damp air and chemically impregnated water are nearly always present in mines, and the "copper" water encountered in copper mines is so injurious to iron alloys that the pumps used to remove it are commonly made of pure bronze. Ropes which are alternately wet and dry corrode very rapidly, but it is interesting to note in this connection that ropes which are continuously wet are subject to comparatively little corrosion even when the water contains a small percentage of chemicals. Wire ropes exposed to sea air corrode rapidly unless protected and for this reason ropes used on ocean going ships are usually fabricated from galvanized wire.

Corrosion has a number of bad effects upon the rope if not properly combatted. The first result is that the lubricant applied to the rope during fabrication is destroyed leaving the steel dry and exposed to the acids. A rope that has become dry cannot remain pliable and the power required to operate it is greatly increased. There is little opportunity for dry wires to readjust themselves in passing over curved surfaces and the uneven stress distribution damages the strand and even causes the wires to break. It has been shown that a transmission rope which has been allowed to become dry will become so hot in a short time that it cannot be touched and, moreover, will make a very audible crackling sound in passing over the pulleys. This heat indicates pronounced frictional wear and a condition of rapid deterioration. A well lubricated rope under the same conditions will scarcely become warm.

With the protective film once removed from the wire, corrosion proceeds at a rapid rate and the finer the quality of the steel in the rope the faster will the destruction be propagated. The corrosion pits the wires and reduces their cross-sectional area. The rope is then more rapidly broken up in passing over the drums, not only because of decreased resistance but also because the rope acts more like a solid bar than a flexible cord.

Corrosive gases and liquids are very injurious to the hemp core of the rope, rendering it dry and inelastic and absolutely incapable of performing its function in the rope. When the hemp core falls to pieces the rope is bound to collapse to a certain extent, seriously impairing its strength. Moreover, the lack of the cushioning effect provided by the core exposes the rope to the full violence of sudden shocks. When a suitable lubricant is used upon the rope the hemp core will become impregnated with it and thus serve as a reservoir from which a little lubricant is exuded with every movement of the rope. Care in the form of proper lubrication not only saves the core but also enables the core to protect the wires from corrosion long after the lubricant originally applied to them has been destroyed.

A wire rope will slowly wear out with use just as any other machine wears out, but it is imperative, in order to get the full measure of service from a wire rope, that it be thoroughly lubricated both inside and out with



EXTERIOR APPEARANCE OF A PERFECTLY LUBRICATED WIRE ROPE

a highly specialized preparation capable of reducing mechanical wear to a minimum and of absolutely resisting the inroads of corrosive substances. Many products are on the market which will reduce friction. There are some which will prevent corrosion, but those which will do both are scarce indeed. The peculiar operating conditions to which wire ropes are subjected, admittedly make their lubrication a very difficult matter. Ordinary black oil and so-called waste oils are used on ropes but they possess little value for this purpose as they are rapidly thrown off, do not penetrate to, or preserve the core, and are worthless in resisting the attacks of moisture.

Corrosion in unsuitably lubricated wire ropes is especially serious because of the fact that it goes on unrestricted in the interior of the rope when the exterior appearance leads one to believe that it is thoroughly lubricated. If a rope is obviously in a bad condition it is bound to be regarded with suspicion but a rope may be falling to pieces inside and yet present a beautiful external appearance. The efficient wire rope lubricant is one that penetrates to the very core of the rope. If the innermost wire is coated the rest of the rope need cause no concern.

It is assumed by many engineers charged with the care of wire ropes, that the initial application of lubricant, made by the manufacturer, should be sufficient to protect the rope for all time. Examination of numerous wire ropes has shown that even under the most favorable operating conditions the initial application of lubricant lasts only a short time, and without its protection the wires begin to wear and the core soon dries up. Periodical applications of a suitable lubricant are absolutely necessary to the efficient operation and longevity of wire ropes.

The ideal wire rope lubricant is one that protects all parts of the rope from corrosion and wear. That is, it must preserve as well as lubricate. The primary requisite of the wire rope lubricant is that it penetrate between the wires to the core, saturating it and keeping it moist and firm. Although the lubricant must be fluid enough to fill the

THIS IS WHAT THE INTERIOR OF A WELL PRESERVED ROPE LOOKS LIKE

interstices between the wires, it must not drip and throw from the rope and drums even at comparatively high temperatures. It must possess pronounced adhesiveness, forming a waterproof coating upon the rope, but it must remain plastic at all temperatures in order that the rope may be pliable. It is necessary that the lubricant should stay on the rope for long periods without renewal, that is, it should not be readily wiped off and should be insoluble in water and impervious to damp air. Another essential characteristic is that the wires and drums should receive continuous lubrication in order that internal and external wear may be reduced, but the lubricant must not contain material which will build up in the grooves of the sheaves and drums.

The chief objection to a great many lubricants is that they form a hard shell upon the outside of the rope and this cracks, chips, or peels off exposing the bare wires to corrosion and rust. A suitable rope lubricant must remain plastic at all temperatures. Finally the lubricant must be so made as to be readily applied in a thin film to the rope. It must not evaporate and it must be free from acids and alkali.

Prolonging the life of wire ropes is strictly a matter of dollars and cents and is worthy of the serious consideration of all who are buying and using them, but there are factors connected with their operation which are of much greater importance. Millions daily entrust their lives to wire ropes and the failure of one of these might easily result in mutilation and death. Furthermore, the failure of a wire rope in a manufacturing plant would not only endanger human life but would also cause other damage, and perhaps throw a number of people out of work. Safety is always promoted by inspection, but many a rope in an advanced stage of decay has deceived a conscientious inspector, and they will continue to do so until people using wire ropes come to realize that they wear inside as well as outside and that a nice appearing coat of lubricant on the surface of a rope is NOT necessarily lubrication.

Cement Mill Lubrication

It may safely be said that in no industry is machinery subjected to more severe service than that met with in the cement mill. Cement mill machinery operates in the presence of dust and grit and must run continuously day and night for practically a whole year without a halt. It is often the case also that the breakdown of one or more machines may shut down some other part of the plant. Moreover, most of the machinery used in the manufacture of cement is heavy and expensive, consequently, its lubrication is a matter of no small importance, not only because correct lubrication protects the machines and prolongs their lives but also because of its ability to lower operating costs.

Portland cement is made in three different ways:—

(a) Wet process.
(b) Semi-wet process.
(c) Dry process.

These processes vary somewhat with different raw materials, each individual plant employing methods and machinery most suitable for its own peculiar conditions. No two plants receive the same raw materials, no two plants operate under precisely the same conditions, and no two cement plant engineers agree as to what is the most suitable combination of machinery to employ. Consequently, it is impossible to discuss the machinery used in the cement mill on the basis of a standard sequence of operations. In this article we shall not attempt to describe any particular plant, but shall deal with the lubrication of the individual machines found in the modern Portland cement plant in somewhat the order in which they are encountered during the flow of the materials through the plant.

The wet process for making Portland cement is employed when marl is the calcareous element. The marl and the required amount of clay are mixed together in a "pug" mill to form what is known as "slurry." After thorough mixing the slurry is further ground in tube or wash mills and pumped to the storage tanks over the kilns. From this point the process is identical with the dry process. Although the wet process has many advantages, it is not extensively employed because of the quantities of fuel required to dry the materials and will not be discussed further.

The semi-wet process is sometimes called the semi-dry process. Both of these terms are misnomers as this is really a wet process. The semi-wet, or semi-dry, process is simply a slurry process applied to dry materials to facilitate mixing and is not extensively used. The limestone and shale are pulverized as in the dry process and then mixed with water in a pug mill. After grinding the slurry is pumped to tanks over the kilns after which the materials are subjected to the same treatment as in the dry process.

A large percentage of the Portland cement produced in this country is made by the dry process. As the first step in this process the clay, shale, cement rock or limestone are conveyed from the quarry to the stone house

ALLIS-CHALMERS No. 18 GEAR DRIVEN GYRATORY CRUSHER

for grinding. The mechanical equipment in the stone house consists of crushers, hammer mills, pulverizers and dryers. It used to be the custom to use several small crushers in the stone house, but the modern practice is to dump the raw material into one large crusher and then submit it to secondary grinding in two or more smaller crushers. Because of their limited capacity jaw crushers are not used in the modern cement plant to any extent, although they are sometimes used to reduce very large rocks for the gyratory crushers. Preliminary crushing is now usually done in one or more gyratory crushers.

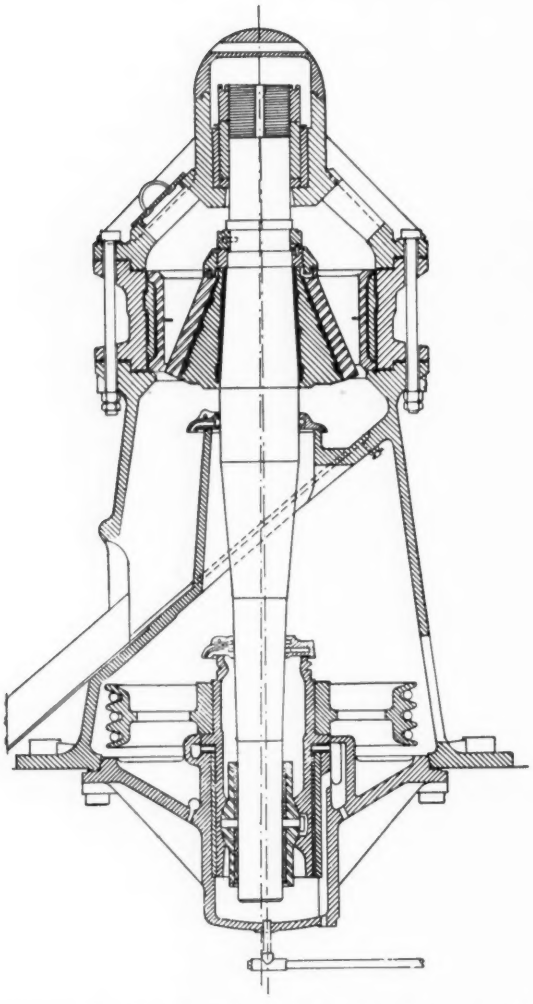
The accompanying illustrations will convey to the layman some idea of the construction and method of operation of the gyratory crusher. The shaft and crushing head do not revolve and grind the rock. The eccentric at the bottom of the shaft imparts to the crushing head a circular rolling motion which causes it to approach successively every point of the interior of the throat. This action results in a continuous breaking of the material which then falls through at that point of the throat from which the head is most distant.

From the outward appearance of a gyratory crusher one might be led to believe that its lubrication is a very simple matter. Such is not the case, however. Due to the peculiarities of its construction and the rough work it is required to do, its lubrication is a matter of considerable difficulty. Not only are all the bearings exposed to a great deal of sand and dust, but some of them also carry tremendous loads and occasionally are exposed to very low temperatures.

Gyratory crushers may be divided into two great classes; namely, those with geared drives and those with gearless drives. The accompanying illustrations show an example of each type of construction. The gear driven crusher has two points requiring lubrication which are not found on those employing the gearless drive. These are the countershaft bearings and the teeth of the gears.

Countershaft bearings on crushers are occasionally of the ring-oiled type but because of the loads which they are forced to carry, to say nothing of the grit which gets into the bearings, this seems an unnecessary refinement. The speeds of countershafts rarely exceed 600 R.P.M. and, consequently, they can be quite adequately lubricated with cups provided the proper grade of oil is used. The ring-oiled bearing has a great advantage over other types, however, in that the grit is washed from the journal and carried into the reservoir, but unless the reservoir is large and cleaned frequently, the grit will accumulate and abrade the journal and bearing severely. Wherever it is possible, countershafts should be fitted with outboard bearings as these steady the shaft and take a great deal of load off the main bearing. A heavy engine or machine oil usually proves successful in the countershaft bearings of gyratory crushers, but it is essential that the oil have a low pour test in order that it may flow readily at the low temperatures to which crushers are sometimes exposed.

The gears of gyratory crushers are subjected to very hard service. Dust rings are fitted about the shaft where it enters the gear case and all openings are covered but despite

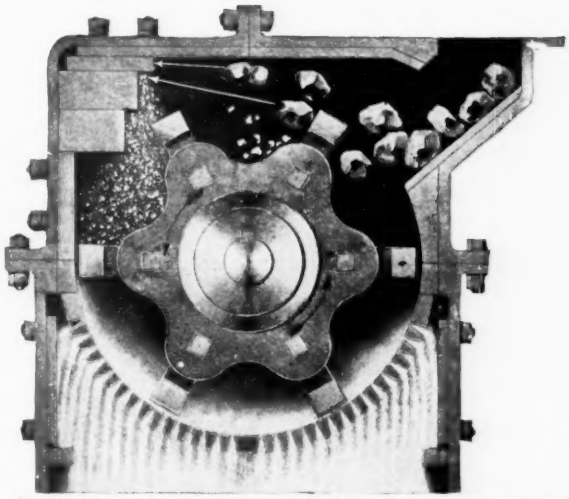


KENNEDY-VAN SAUN GEARLESS GYRATORY CRUSHER

all efforts to prevent it, dust and fine broken rock get into the gear case and mix with the oil or grease upon the teeth. This grit cuts through any light lubricant when caught between the meshing teeth and results in pronounced abrasion. The lubricant used upon these gears should be heavy enough to keep the grit away from the surface of the teeth and should not combine with the dust to form a thick paste which will roll off the teeth and expose them to wear. In addition, the lubricant should resist the drying action of the dust and prevent its packing between the teeth of the gears, as this has a tendency to spring the gears and throws a great deal of unnecessary pressure upon the countershaft bearings and the eccentric. It is very seldom that crusher gears run hot, but they are frequently exposed to cold weather and the lubricant used upon them must have a low pour test. The best lubricant for these gears is a grease possessing pronounced adhesive properties and one that will not flake off at low temperatures. A manhole is always provided in the side of the crusher through which the gears may be easily lubricated while in operation. In some plants the gears are run in a bath of oil, but the oil becomes fouled with grit very quickly and few oils possess sufficient body to make them suitable as a lubricant for gears operating under severe conditions.

The part of a gyratory crusher requiring the greatest amount of attention insofar as lubrication is concerned is the eccentric which imparts the gyratory motion to the shaft. As the eccentric revolves within a bushing and about the shaft, there are two surfaces to be lubricated and, in addition, there is the brass wearing ring which carries the weight of the bevel gear and eccentric. In some machines the bottom of the shaft is designed to fit very loosely in the eccentric in order that it may be tipped from side to side. This throws all the pressure upon a small area near the top of the thickest part of the eccentric sleeve causing it to heat and wear rapidly unless lubricated with the right oil. When crushing hard rock it is sometimes necessary to cool an eccentric of this type with a stream of water. In other machines the shaft is fitted with a ball and socket so that a large area carries the pressure of the eccentric. The eccentric requires a heavy bodied lubricant to carry the heavy loads, but at the same time, the lubricant must not have such a high viscosity that it will not flow to all the wearing parts readily and freely. Oils proficient in one respect are nearly always deficient in the other. This is one reason why so much trouble is experienced with the eccentric. Some operators have lubricated crusher eccentrics very successfully with a light transmission grease, but the heavier the lubricant the greater the difficulties met with in starting and at low temperatures. It has been our experience that a heavy engine oil gives the best results under reasonable operating conditions.

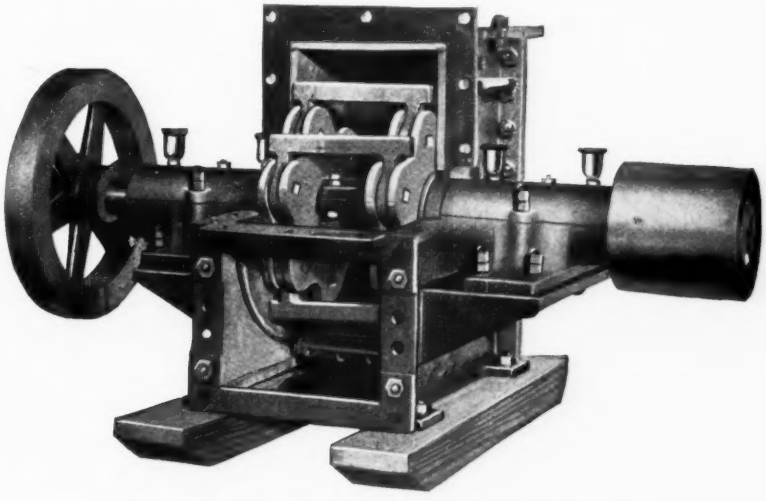
The eccentric sleeve always operates wholly or partially in a bath of oil which serves both as a lubricant and a cooling agent. When crushers are speeded up oil circulation is induced by capillary attraction, the oil passing up through the eccentric journal over the brass wearing ring and back through passages to the reservoir beneath the shaft. This simple oiling system has been found very efficient and when a little fresh oil is added once or twice a day to make up for that lost will give complete satisfaction, provided, of course, that the proper grade of oil is used and that the reservoir is occasionally drained and kept clean. A great deal of trouble will be avoided if a little oil is forced over the eccentric bearing surfaces before the machine is started up. This is especially applicable when crushers are exposed to low temperatures. On crushers having force feeds the eccentric may be flooded by operating the pump by hand, but on those machines depending upon capillary lubrication entirely a small hand pump should be provided for flooding. An additional advantage of the pump is that it may be used to flood the eccentric should it show a tendency to heat. The gearless crusher illustrated is provided with a pump which constantly draws oil from the reservoir, passes it through a filter and returns it to the reservoir for use.



ILLUSTRATING HOW THE HAMMER MILL OPERATES

When the rock issuing from gyratory crushers is too large for rapid drying or to be fed to the pulverizing mills, it is further reduced by passing it through hammer mills. The hammer mill consists of a number of steel hammers which revolve around a horizontal shaft at very high speed. The illustrations show how the hammer mill operates. The hammers whirling around at the rate of 1,000 or more R. P. M., strike the fragments of rock and hurl them with such force against the breaking blocks that they are shattered by the impact.

Hammer mills have only two bearings requiring lubrication; one at either end of the main shaft, but because of the speed at which the mills revolve these require considerable



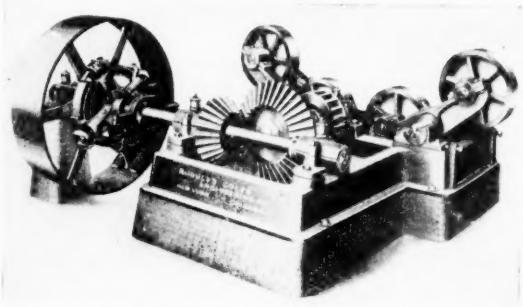
HAMMER MILL BUILT BY THE K. B. PULVERIZER CO.
NOTE THE LONG BEARINGS

attention. Some hammer mills are fitted with long ring-oiled bearings, but when these are used they should have ample storage reservoirs so that the oil may have every opportunity to cool and the dust washed from the journals may have a chance to settle out of the oil. Any good machine oil of medium viscosity will prove satisfactory upon hammer mills fitted with ring-oiled bearings. Cup grease will usually give the best service upon plain bearings.

Before the pulverized rock can be reduced to a powder it is necessary to remove all the moisture which it may contain by passing it through rotary dryers. These are large cylinders 4 to 8 ft. in diameter and from 40 to 80 ft. in length. The dryers are slightly inclined downwards so that the rock entering at the upper end gradually slides through. A fire is maintained at the lower end by means of fuel oil, gas, or coal and the hot gases are blown through the dryer in contra direction to the movement of the rock. Dryers are supported on two riding rings and driven by a pinion which engages a girth gear surrounding the barrel of the dryer.

As dryers revolve only 4 to 6 times a minute their speed does not create any unusual lubricating problems. The difficulty is principally due to the ever present dust and the heat which is radiated from the dryer, although the weight of the larger varieties may cause some trouble.

The carrying and thrust mechanism of dryers is not particularly difficult to lubricate. The journals of the bearing wheels and thrust rollers are arranged for hand oiling and may be successfully lubricated with black oil, but some means should always be adopted to keep the grit out of the bearings. When it is necessary to maintain a high temperature in the dryer, the radiated heat may thin down oils to such an extent as to make them useless for lubricating the bearing wheels and thrust rollers. When this is the case the bearings of the carrying mechanism should be arranged for grease lubrication. Yarn or sponge grease



DRIVING AND CARRYING MECHANISM OF A ROTARY DRYER—BUILT BY THE RUGGLES-COLES CO.

should be used under these circumstances.

Although greases have a comparatively narrow range of service they are excellent lubricants when properly selected and applied, and might well be used to a greater extent in the cement mill than is the case at present. In bearings revolving at slow speed where it is necessary to maintain a film of lubricant possessing great body, greases are unexcelled. Grease is cleaner, it does not require such frequent applications and the lubricating film remains after the machine comes to rest, thus precluding the chance of frictional wear while the machine is starting up.

The gears of the driving mechanism, and notably the girth gear, are kept pretty hot by heat radiated from the dryer and, like everything else in the plant, are exposed to a great deal of dust. The lubricant used upon these gears should be able to resist the action of the heat so that it will not thin down and run off or otherwise permit metallic contact. It should also prevent abrasion by grit and resist the drying action of the dust. In addition, it should have a higher liquefying point than the lubricant used upon the bevel gears of the gyratory crusher and sufficient body to prevent the teeth coming together. The lubricant used upon these gears will also prove satisfactory on the contact surfaces of the riding rings and rollers. The bearings of the gear shafts are arranged for hand lubrication and either a heavy oil or light grease will give satisfaction, the latter to be preferred when much heat is radiated from the dryer.

Because of its length it has been found impossible to publish this entire article in one issue of LUBRICATION. The balance of the article, which deals with the lubrication of the machinery employed in other parts of the plant, will be presented in later issues of LUBRICATION.